

Measure Achilles heel of plasma ion sources: conclude they are viable

One disadvantage of using a plasma ion source is that un-ionized gas flows out of the source causing beam losses and charge exchange. Usually the gas pressure drops rapidly after emerging from the source aperture so the total beam loss in the injector due to this gas effect is not a very serious issue. Nevertheless, ions produced by charge exchange near the extraction region have energies near that of the main beam and therefore can stay with the main beam for a long time. These ions have a slightly lower energy and thus appear as a "tail" in the energy dispersion curve. Producing a significant amount of charge exchange ions would be a



Fig. 1. Electrostatic beam energy analyser.

serious concern because these ions are accelerated to full energy before they are lost in the final focusing stage.

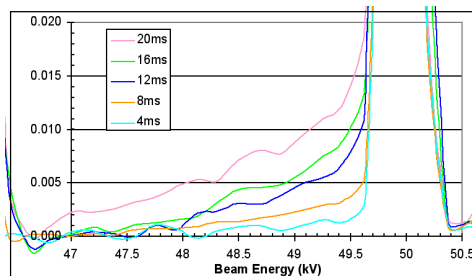


Fig. 2. Energy dispersion of the beamlets at various source pressure (4ms gas puff equals to 2 mTorr).

component was proportional to the gas pressure in the source. The graph is normalized such that the main peak (at 50 kV beam energy in this graph) has amplitude of unity. The width of this main peak was in agreement with the instrumental width of the energy analyzer. At 2 mtorr source pressure, the total amount of low energy component is < 0.3% of the full energy

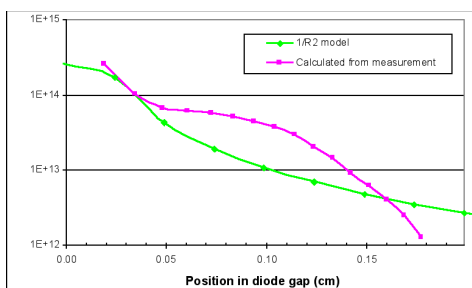


Fig. 3. Gas density in the extraction region.

component under the main peak. The energy spread was over a range of 2 kV below the full energy. Using this data and the published charge exchange cross-section, we calculated the gas density along the beam path. The result is shown in Fig. 3, and compares well to a free expansion gas flow calculation ($1/R^2$ model). – Joe Kwan

Helical pulseline - innovative accelerator for HEDP and HIF

Helical pulselines have recently been considered for ion beam acceleration for HEDP applications. An arbitrary waveform can be applied to a broadband helix to perform acceleration as well as bunching of 10-30 cm long ion bunches. This has potential as a low-cost higher-gradient substitute for induction acceleration. For load-and-fire operation, a beam tube is first filled with ions, then a chosen waveform can be applied to a helix within the tube to accelerate the ions out of the tube and bunch them. The helical structure is a wound coil, Fig. 1, terminated into a matched impedance to prevent reflections which can travel back up

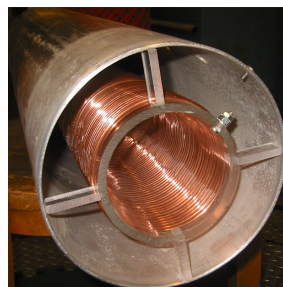


Fig. 1. Air dielectric helix used for low voltage tests.

the helix and distort waveforms. This structure is then placed within a conducting tube. For higher gradients, the helix can be potted in epoxy around a glass tube. The dimensions and epoxy dielectric constant can be adjusted to determine the impedance and wave speed of the helix.

Low voltage testing has been performed on the helix to measure the wave speed, bandwidth limitations, and coupling methods. In Figure 2, we show that the input waveform is preserved at the desired wave velocity. The helix can be driven directly at the full voltage, but a preferred method of driving the helix is by inductively coupling through a transformer primary to achieve a voltage step-up. This coupling method allows for a lower drive voltage, making the high voltage vacuum feedthrough more compact. Voltage step-up ratios of 10:1 have been demonstrated.

The acceleration gradient of these structures is limited by the axial electric field on the vacuum side of the glass tube. The voltage breakdown limits still need to be demonstrated, but acceleration gradients of 2-5 MeV/m should be possible.

– Will Waldron, Lou Reginato and Dick Briggs.

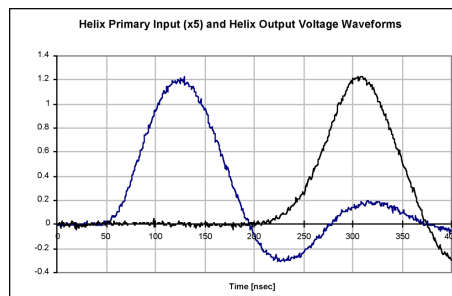


Fig. 2. Voltage waveform in and out of the air dielectric helix showing 5:1 step-up from transformer coupling and a measured wave velocity of 4.7m/us